



## **Measures in generation, demand and trade to reduce the impact and cost of an increasing share of intermittent RES in the electricity generation**

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# Response Options Aimed at Increasing the Contribution of Variable Energy Resources in the Electricity Supply Workshop Roskilde June 10

**Measures in generation, demand and trade to  
reduce the impact and cost of an increasing  
share of intermittent RES in the electricity  
generation**

Henrik Klinge Jacobsen and Erika Zvingilaite, Risø DTU



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# Contents

- Impacts and major categories of response options
- Generation and demand response options
- Wind impact on spot prices and possible mitigation from demand response, illustrative example
- Actual example from DK price movements
- Which options could mitigate the price variations and the price reduction in different situations?
- Reduction of variation in intermittent generation and possible price impacts
- Are the illustrated impacts relevant in a broader EU perspective? – EU RES targets and the timing



# Problems and Impacts

## Focus on markets

- **Variability of intermittent sources - markets**
  - Price variation high
  - Lower prices at times of high wind output
  - Lower revenues for both intermittent generators and other generators
- **Unpredictability of intermittent sources**
  - High balancing costs
  - High and inflexible reserve requirements
  - Low capacity values for intermittent generators



# Different categories of options to mitigate the problem of price variations

## Two major alternatives

- **Reduce the output variations**
  - Interconnection capacity
  - Flexible generation technologies in mix
  - Mix of intermittent generation technologies
  - Dispersed location of intermittent technologies
- **Demand options that adjust to output variations**
  - Increase price flexibility – demand response (regulation, technology)
  - Storage of electricity or heat
  - New demand technologies (heat pumps, hybrid electric cars)



# Generation technologies and variability

- Flexible generation technologies wanted
  - Low stop and start costs as well as fast regulation properties
  - Reasonable part load characteristics – efficiency, emissions

Combination of resources: intermittent and others

- PV and wind power combination reduce variation
  - Somewhat uncorrelated production but dominated by cost differential
- Wind power and CHP can work
  - CHP can only be flexible with heat storage and correct subsidy scheme for CHP
- PV or Wind and Hydro
  - Excellent combination with sufficient hydro storage



# Demand options

- Demand response reduce the variation in load and thereby reduce the impact of;
  - Low intermittent generation at times of high load
  - High intermittent generation at times of low load
- Wholesale prices will with unchanged total demand be reduced and their volatility also reduced
- New demand technologies made available might benefit from low prices and average prices even increase because total demand increase
- Different options exists:
  - time of use tariffs, day ahead pricing, peak pricing and real time pricing etc.



# Demand response implementation

Demand response increase require the availability of

- Metering (but not necessarily for all)
    - and billing that transfer the price signals to final consumers
  - Tariff restructuring (especially for costumers with high taxation)
    - increase fluctuations that consider variations in environmental tax elements – including the PSO tariff that finance RES subsidies
  - New demand technologies available (heat pumps, hybrid electric cars)
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- Interacts with storage – storage increase demand response

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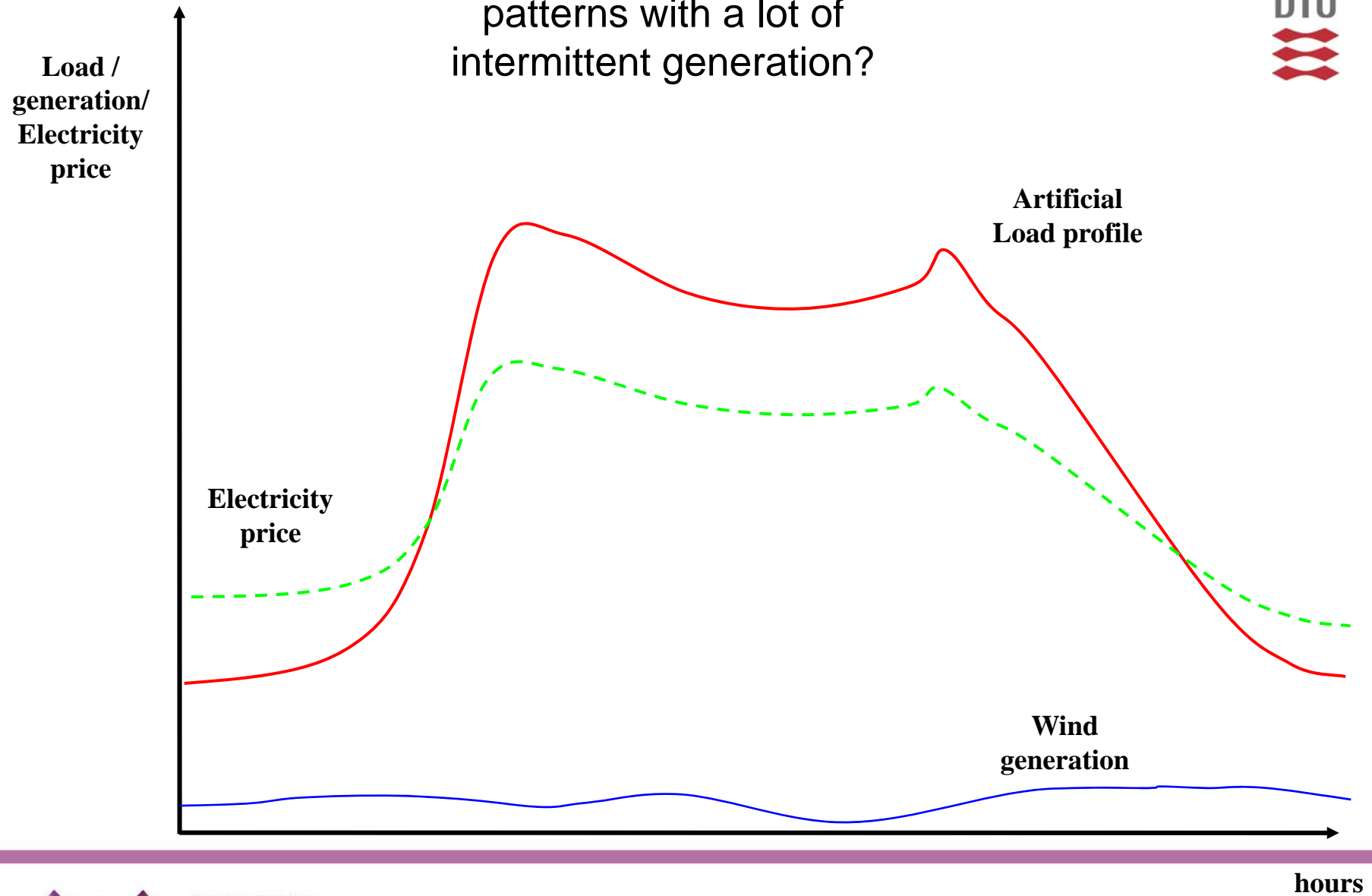


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What happens to price patterns with a lot of intermittent generation?



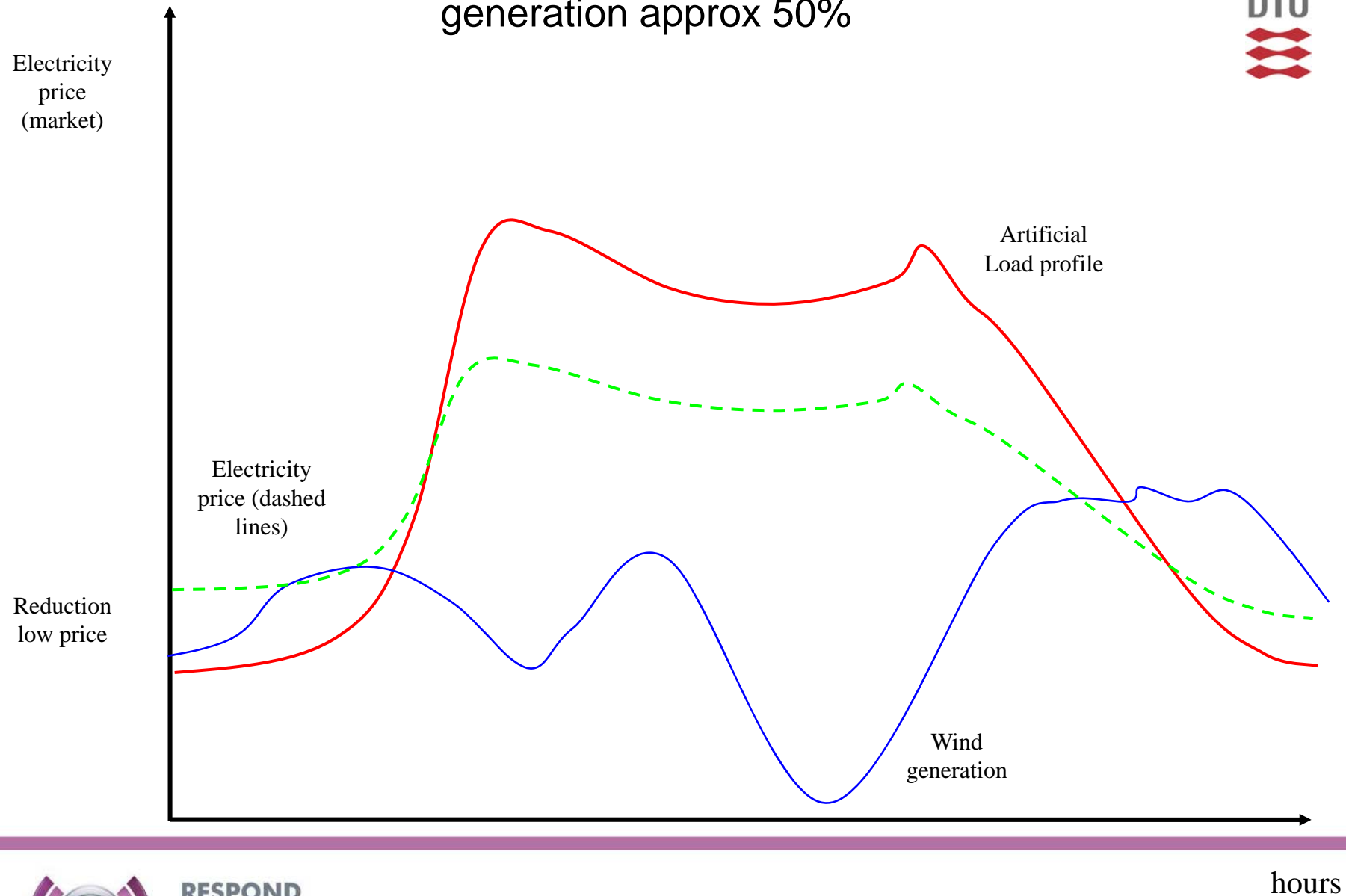
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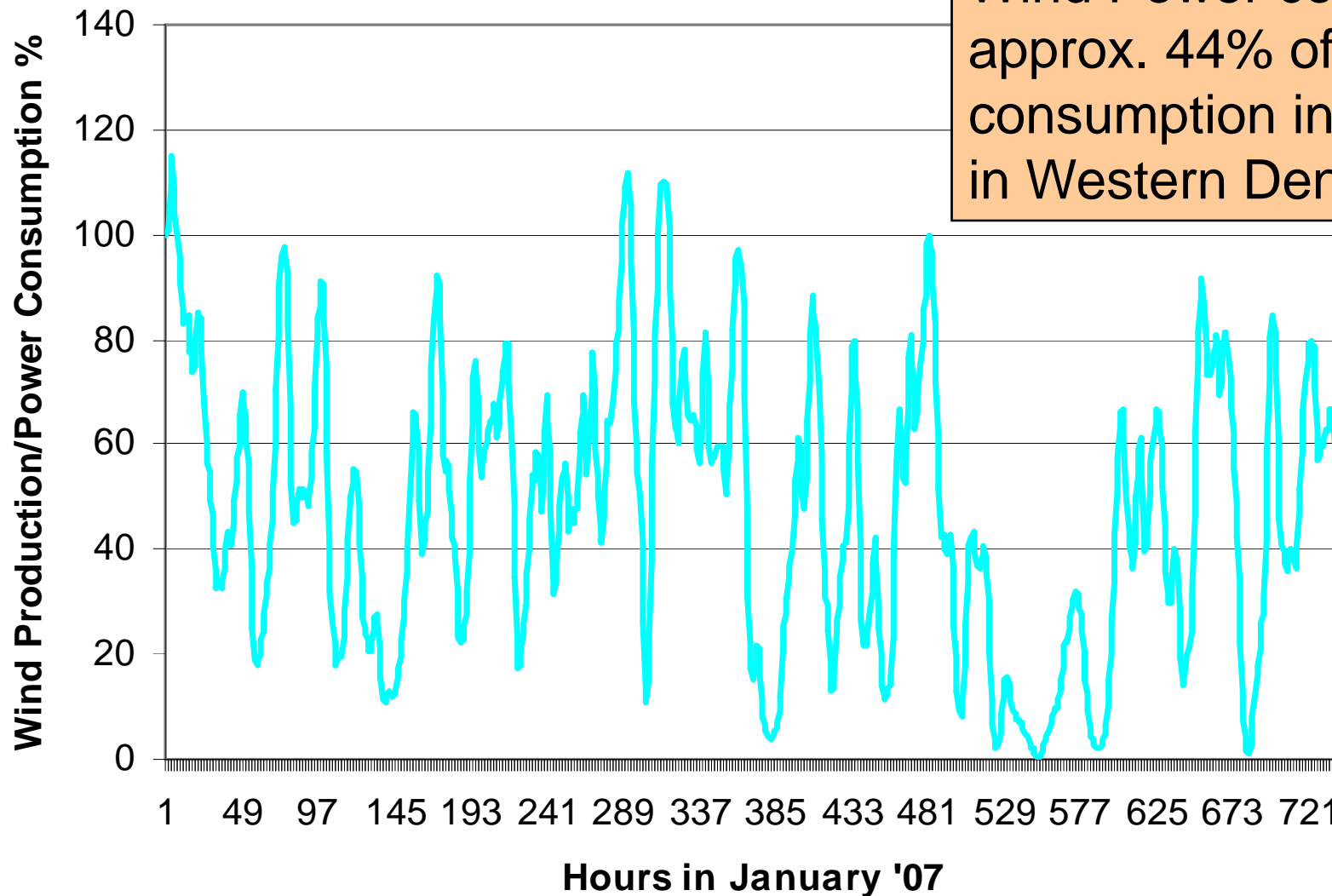
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# Upscaled wind generation approx 50%

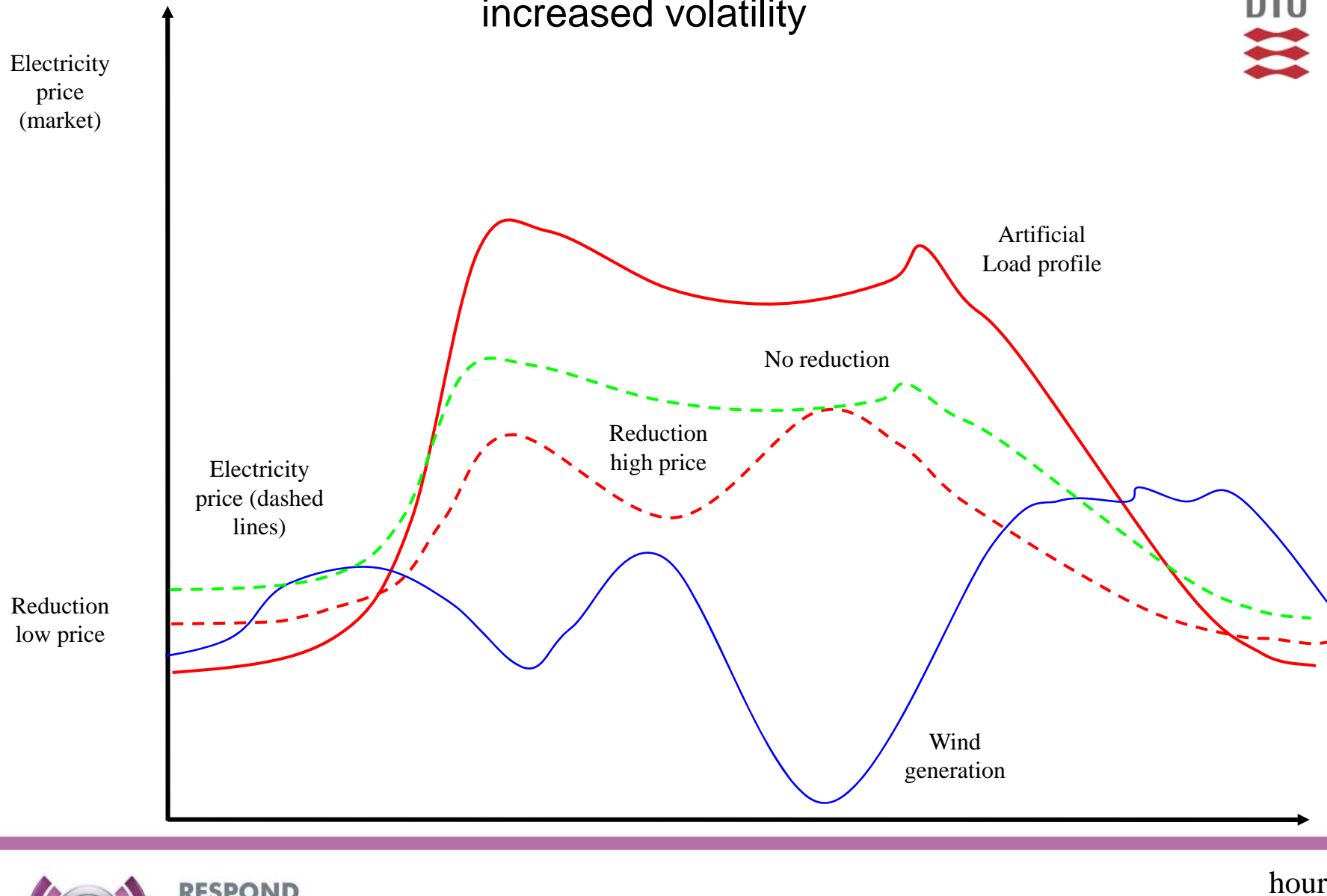


# Wind power in Western Denmark

Wind Power covered approx. 44% of Power consumption in January in Western Denmark



## Lower price and increased volatility



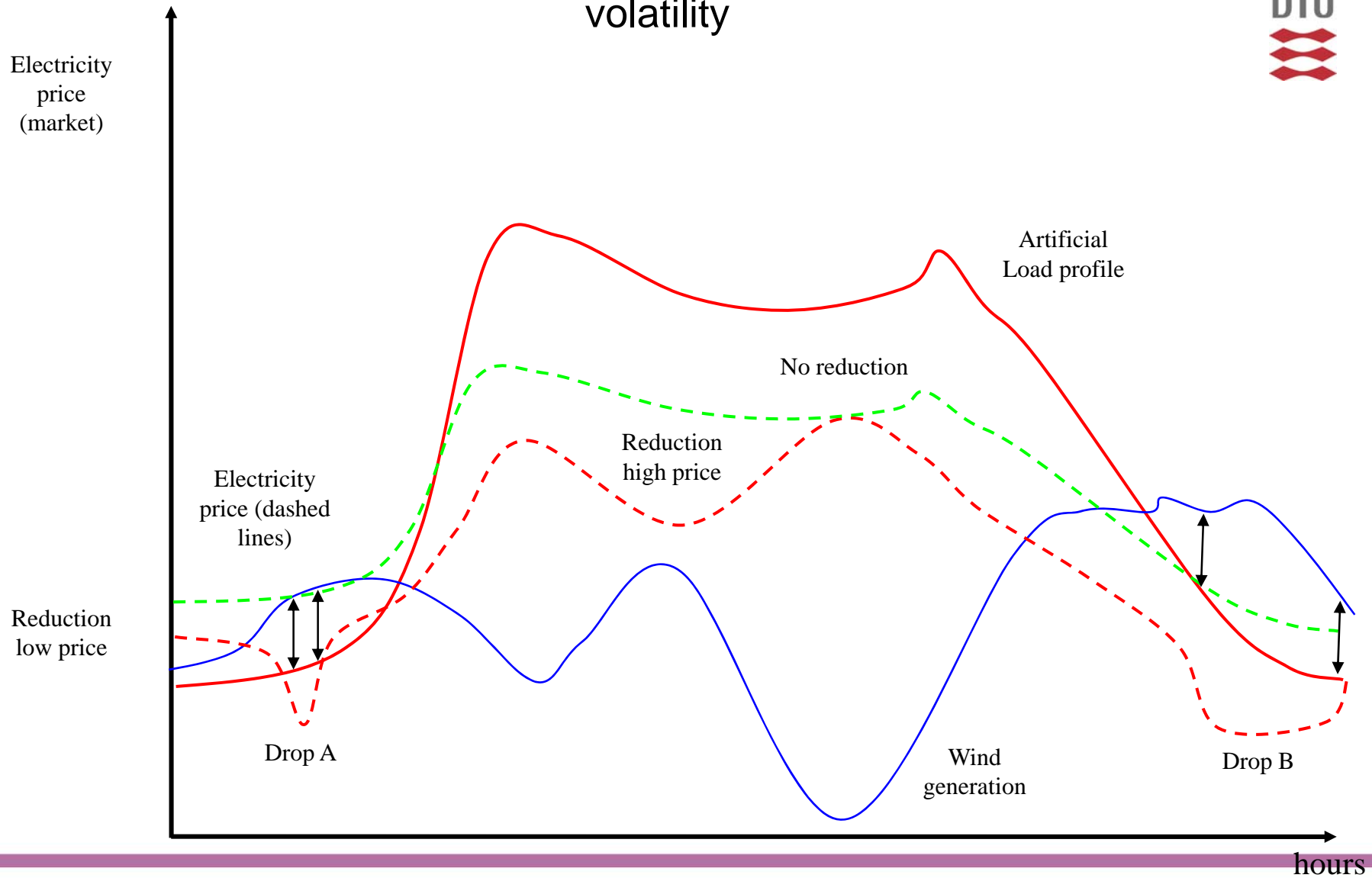
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## Price drops also increase volatility



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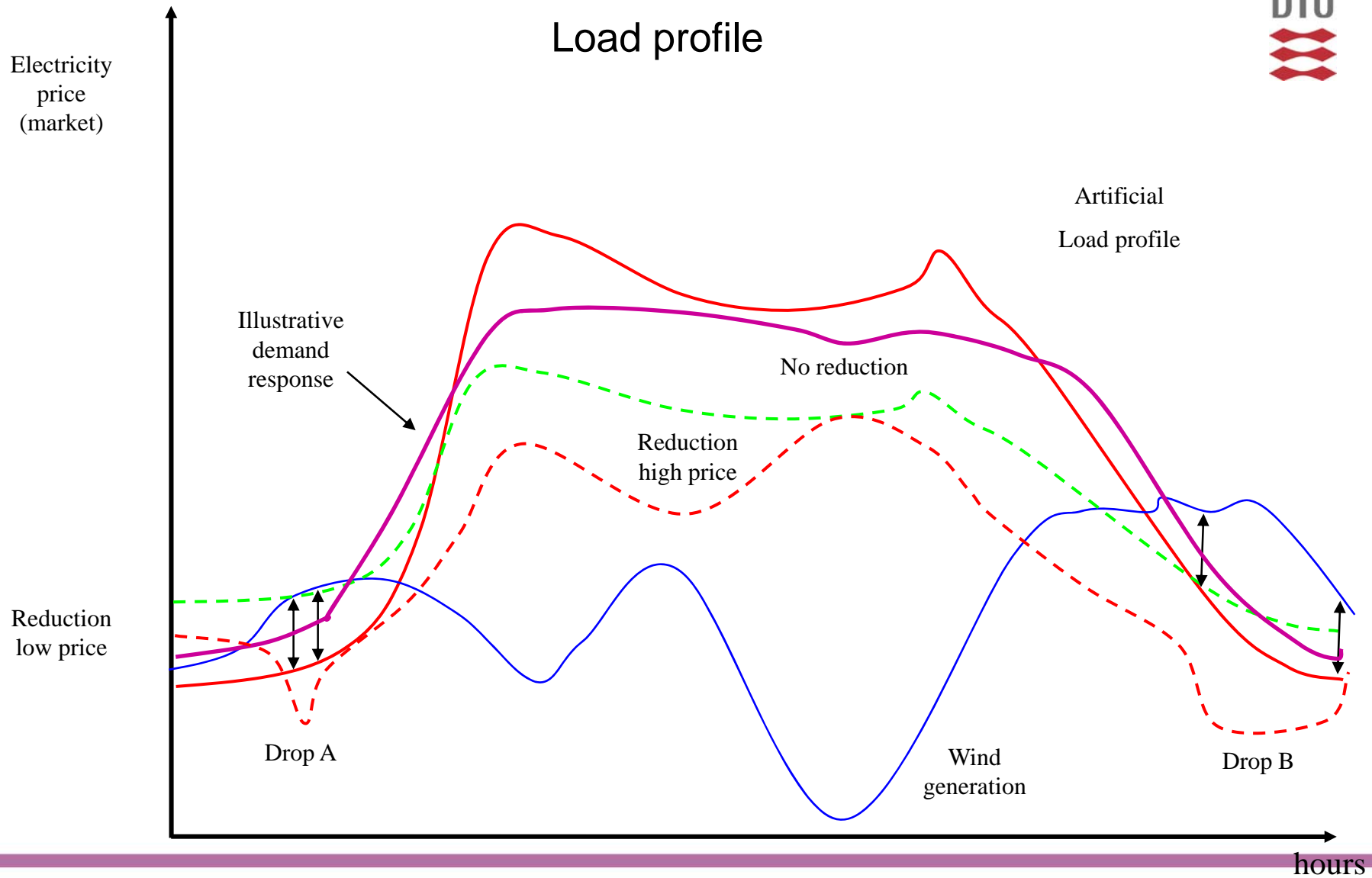
# Demand response – effect on load and prices

- How would the demand response affect the situations where intermittent generation has an impact on prices?
- Load shifting (hours)
- Low prices increase demand (technologies)
- Excess generation and restricted export (interconnection capacities) – reduce the value of interconnection (substitute)



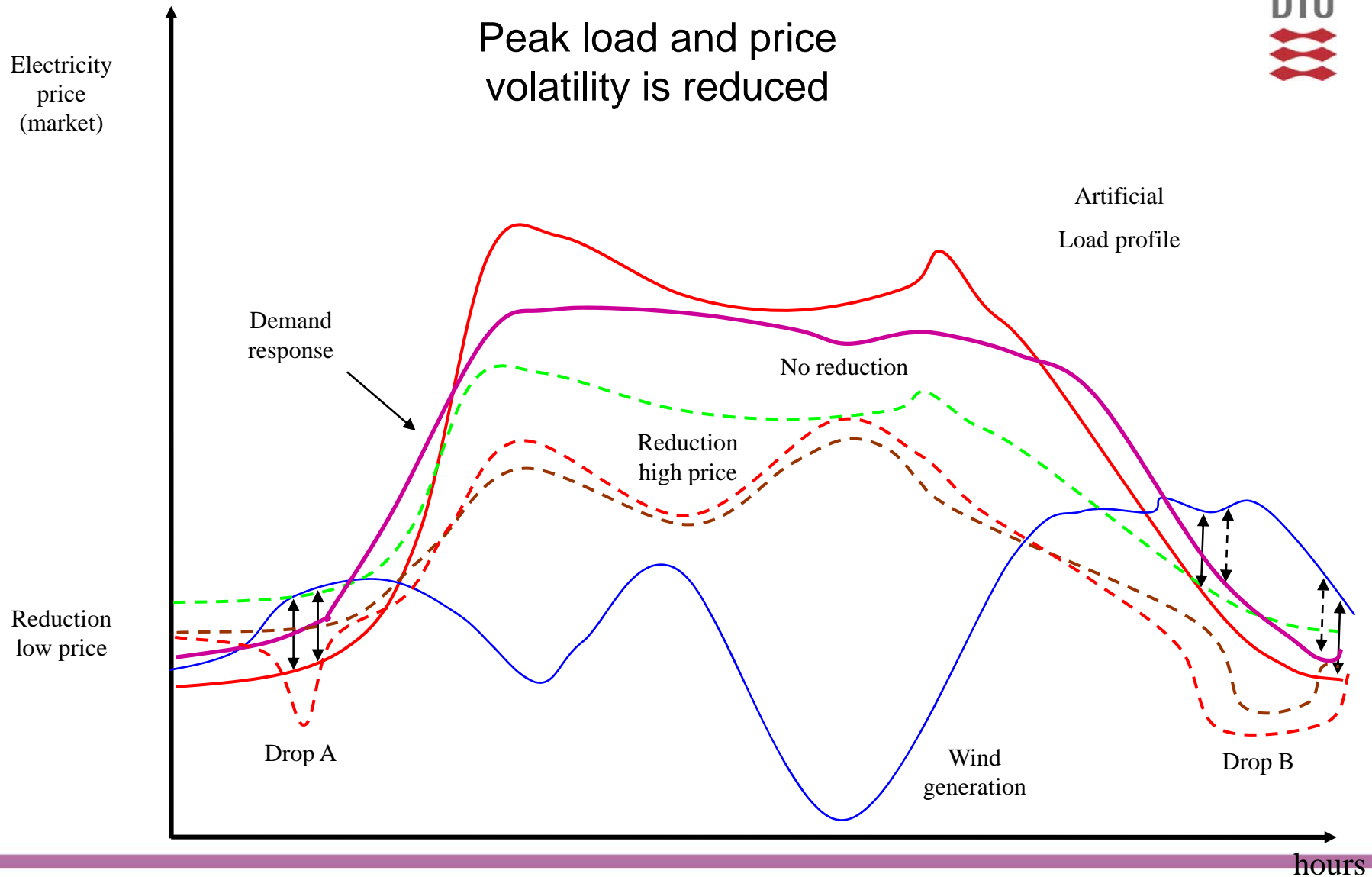
# Demand response

## Load profile



# Demand response

Peak load and price volatility is reduced

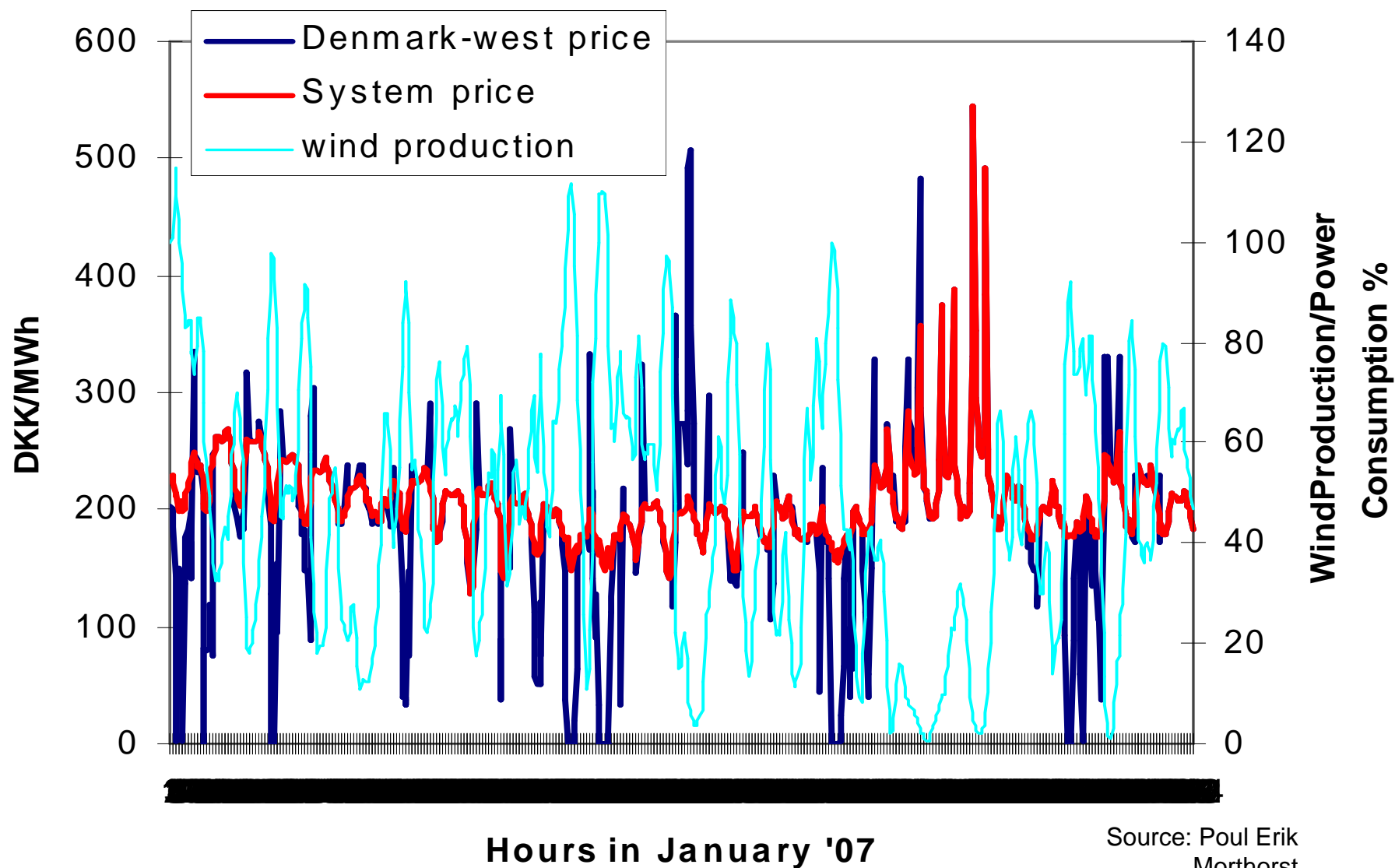


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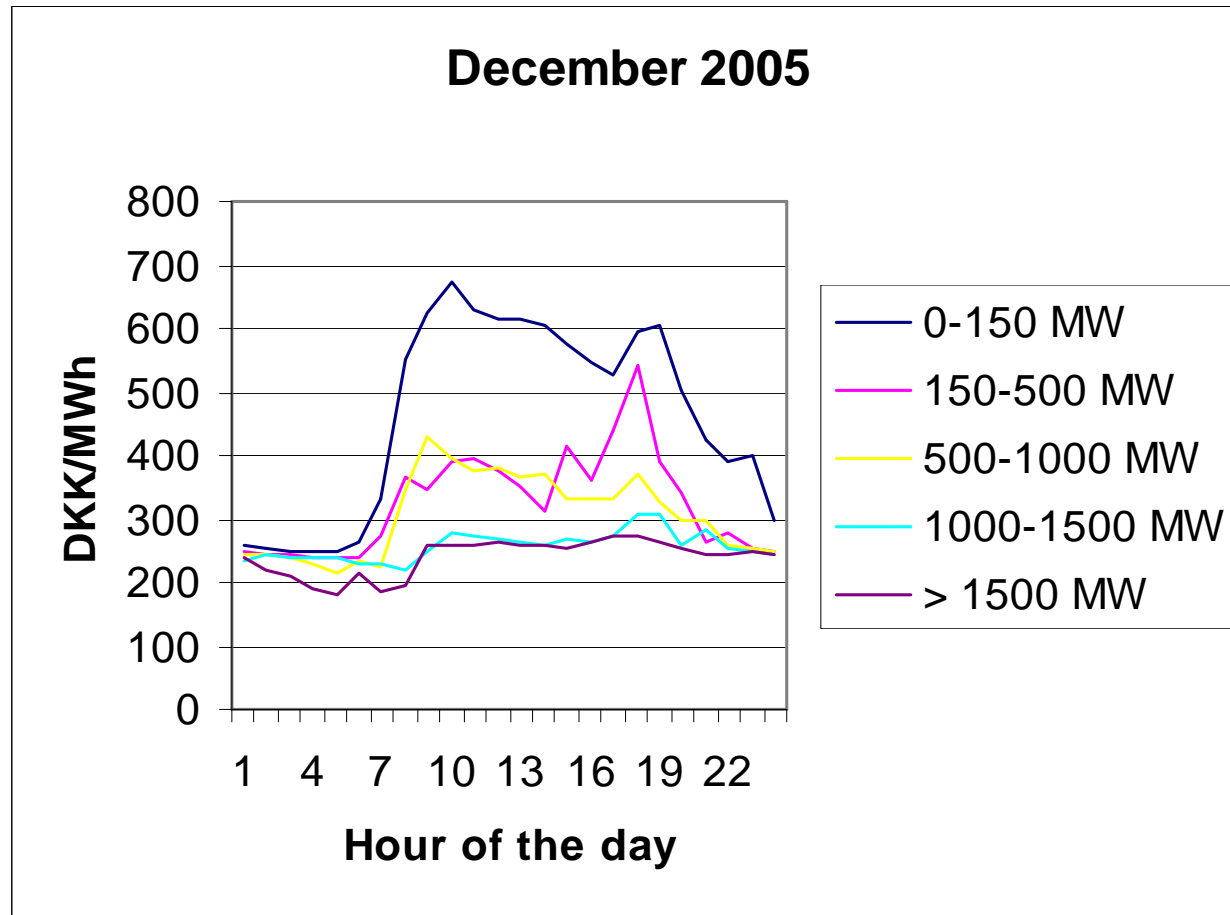
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## Impact on Spot Price: DK example



# Impact at the Western-Denmark power market



Source: Poul Erik  
Morthorst

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# Interconnections, storage and demand response

- Interconnection capacity
  - Reduce the impact of variability on prices
  - Reduce the reserve requirement
- Storage technologies
  - Use the variability of prices to store electricity or heat related to CHP – mainly short term (hours)
  - Hydro storage – both in short term and for longer term storage
- Demand response
  - Reduce variation of prices – flattened duration curve
  - Regulatory part – requires price pass through
  - Technological part - investments

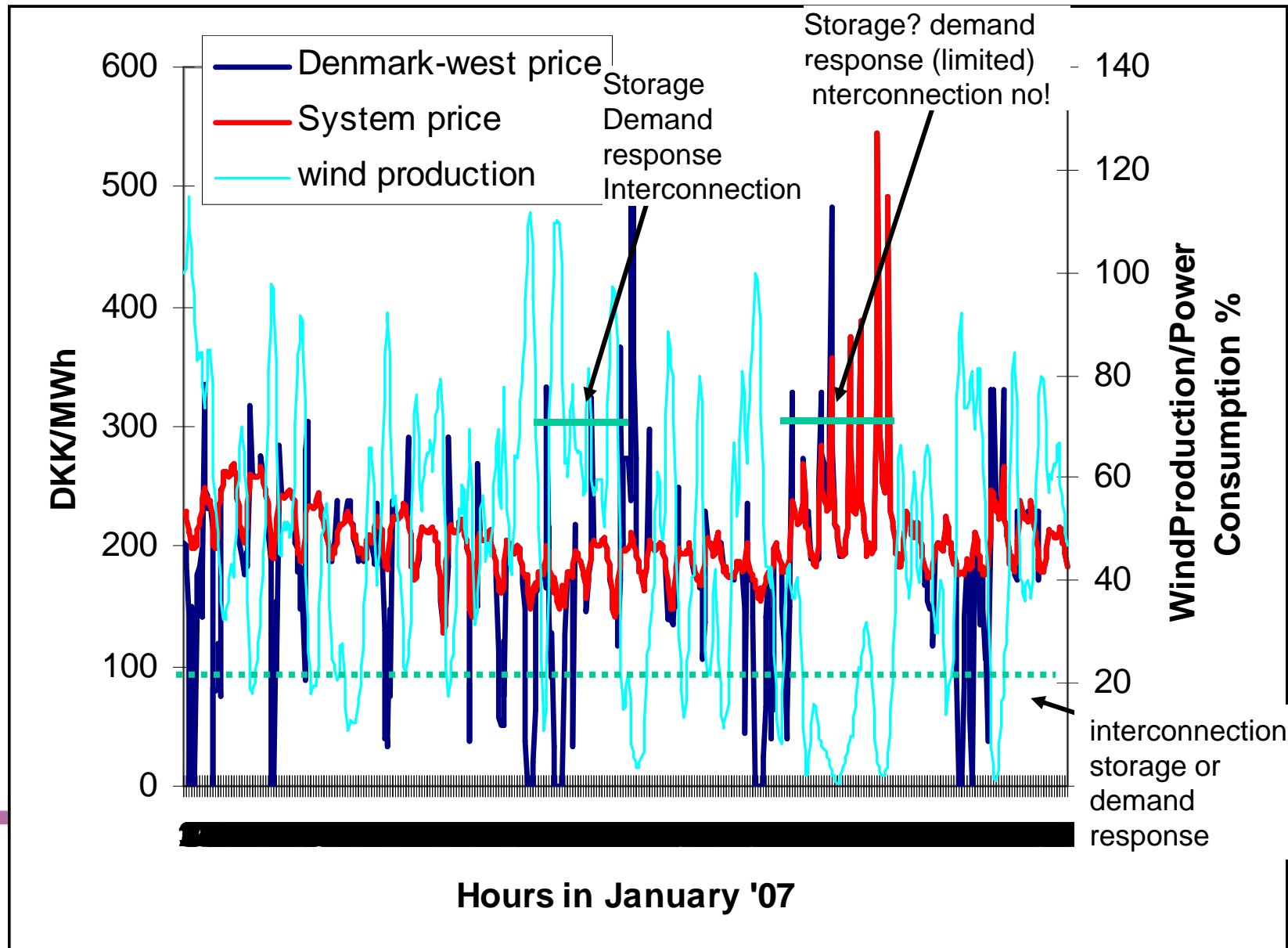


# Example of price impact reduction in a system with high intermittent shares and interconnection constraints

- Why is the low prices a problem?
- In a system with high intermittent shares there are unattractive low prices – from the generators view
- There is a lot of short term price variation – adjustment cost
- There might be longer periods of high prices
- Lower spot market price is reducing the incentive to invest for all generation (main revenue from spot market)
- Especially wind generators will experience low prices reducing the incentive to invest (share of revenue from market)



# Demand response, storage or interconnection



# Are the impacts and the options illustrated relevant?

- RES intermittent generation shares are only high in a few countries?
- But already at low shares networks will experience the impacts
- If EU targets are becoming reality the illustrated example might become the average rather than just a Danish extreme
- Therefore identifying a mix of options to mitigate the intermittent effects is vital to have a smooth implementation of the RES targets



# Timing and options

- First we cannot wait to implement options to 2020 as interim targets are binding
- Different response options are relevant at different time horizons
- Targets are gradually increased up to 2020 – so we must make sure that options implemented in 2015 don't interfere with options planned to be in effect later on.
  - if we build interconnection
  - low prices during night-time to be exploited by hybrid (electric) vehicles will not be available (DK case)



## Concluding remarks

- New EU Directive including RES targets will increase the impacts that must be addressed due to high targets
- Market price effects of intermittent energy will become larger
- A larger share of RES generation will be market based
- Variability in intermittent generation could be matched by flexible units in generation mix and cheap storage technologies
- Interconnection and demand response are important options – but they must be evaluated taking account of each other





## Prioritised options

- **Interconnection should always be considered – with the highest benefits for areas that differ in generation structure and demand pattern**
- **Demand response is an alternative that could contribute to reduce intermittency problems**
- **Dispersion of intermittent generation across countries or regions will also be beneficial (transmission constraints)**
- **Cheap storage technologies where available is also a substitute to interconnection and increase demand response (hydro, heat)**
- **Flexible generation mix**

**Finally all options must be evaluated taking account of each other and optimal mix is not identical for all areas/countries**

